Origin Of Resistivity Change In NiO Thin Films Studied By Hard X-Ray Photoelectron Spectroscopy

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ABSTRACT

The flash memory technology driving the market of portable electronic devices is rapidly approaching miniaturization limits. As the industry moves toward memory cells with 22-nm lateral features (1) charge trapping becomes increasingly difficult.

Therefore a new class of non-volatile memory devices rather based on resistivity change is being intensively investigated by the scientific community. OxRRAM (oxide resistive random access memory) are advantageous in terms of data retention, low power consumption, and 3-D architecture compatibility. The transition metal oxide compound surrounded by two metallic electrodes can be tuned between a high resistive state and a low resistive state by the application of a bias. However, the understanding of the resistive switching is critical for further device integration and optimization. Several models (2-4) have been proposed to explain the resistance change phenomenon but none confirmed experimentally.

We have investigated the origins of the resistivity change during the forming of NiO based resistive random access memories using hard X-ray photoelectron spectroscopy. This technique allows a non-destructive chemical analysis of the switch structure with information depth of about 30 nm. Energy shifts (Fig 1 left) and band gap states suggest that oxygen vacancies are created in the low resistive state. As a result the resistive switching could correlate with conduction via defects such as electrons traps and metallic nickel impurities. Transport of oxygen atoms could be facilitated by crystalline defects, such as those observed by high resolution cross-sectional TEM images (Fig 1 right). Our results provide concrete evidence of the major role played by oxygen defects in the resistance switching mechanism.

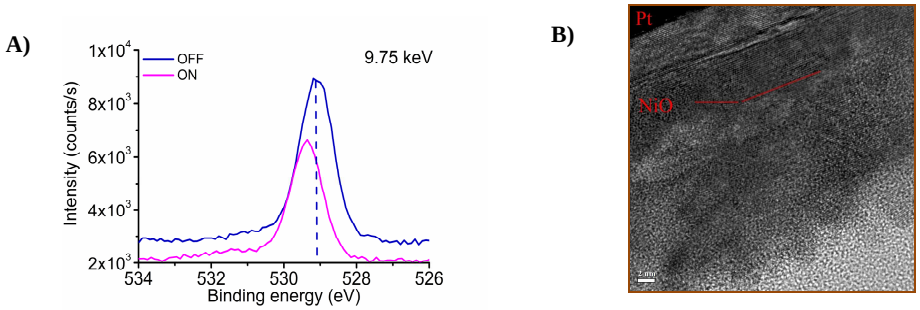

FIGURE 1. A) O 1*s* (b) core level spectra obtained by HAXPES at 9.75 keV. The OFF state represents the oxide high resistance state whereas the ON state represents the oxide in the low resistance state. Bands shift towards high binding energies in the ON state relatively to the Fermi level are probably due to *n*-doping induced by the creation of oxygen vacancies. B) Transmission electron microscopy image of the NiO/Pt stack. Defects were observed in the NiO layer.

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